AD-A045 437 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 11/6
TEMPERATURE CONDITIONS OF THE WORK OF MATRIX DURING HOT PRESSIN--ETC(U)
MAY 77 Y V MANEGIN

UNCLASSIFIED FTD-ID(RS)T-0606-77 NL

1 OF 1
ADA045437

END
DATE
FILMED
11-77
DDC

AD-A045 437

FTD-ID(RS)T-0606-77

0

# FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

TEMPERATURE CONDITIONS OF THE WORK OF MATRIX
DURING HOT PRESSING STEELS
WITH GLASS LUBRICANT

by

Yu. V. Manegin

FOREIGN TECHNOLOGY DIVISION

FTD- ID(RS)T-0606-77

# UNEDITED MACHINE TRANSLATION

FTD-ID(RS)T-0606-77 16 May 1977
CSI76349975 FTD-77-C-000543

TEMPERATURE CONDITIONS OF THE WORK OF MATRIX DURING HOT PRESSING STEELS WITH GLASS LUBRICANT

By: Yu. V. Manegin

English pages: 18

Source: Kuznechno-Shtampovochnoye Proizvodstvo, Nr. 11, 1972, pp. 10-13.

Country of origin: USSR

This document is a machine translation.

Requester: ASD/ETIL





PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

## U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

| Block | Italic | Transliteration | Block | Italic | Transliteration |
|---|---|---|---|---|---|
| А а | *А а* | A, a | Р р | *Р р* | R, r |
| Б б | *Б б* | B, b | С с | *С с* | S, s |
| В в | *В в* | V, v | Т т | *Т т* | T, t |
| Г г | *Г г* | G, g | У у | *У у* | U, u |
| Д д | *Д д* | D, d | Ф ф | *Ф ф* | F, f |
| Е е | *Е е* | Ye, ye; E, e* | Х х | *Х х* | Kh, kh |
| Ж ж | *Ж ж* | Zh, zh | Ц ц | *Ц ц* | Ts, ts |
| З з | *З з* | Z, z | Ч ч | *Ч ч* | Ch, ch |
| И и | *И и* | I, i | Ш ш | *Ш ш* | Sh, sh |
| Й й | *Й й* | Y, y | Щ щ | *Щ щ* | Shch, shch |
| К к | *К к* | K, k | Ъ ъ | *Ъ ъ* | " |
| Л л | *Л л* | L, l | Ы ы | *Ы ы* | Y, y |
| М м | *М м* | M, m | Ь ь | *Ь ь* | ' |
| Н н | *Н н* | N, n | Э э | *Э э* | E, e |
| О о | *О о* | O, o | Ю ю | *Ю ю* | Yu, yu |
| П п | *П п* | P, p | Я я | *Я я* | Ya, ya |

*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> elsewhere. When written as ë in Russian, translite[illegible] as yë or ë. The use of diacritical marks is prefe[illegible] but such marks may be omitted when expediency dictat[illegible]

## GREEK ALPHABET

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Alpha | Α | α | *α* | Nu | Ν | ν | |
| Beta | Β | β | | Xi | Ξ | ξ | |
| Gamma | Γ | γ | | Omicron | Ο | ο | |
| Delta | Δ | δ | | Pi | Π | π | |
| Epsilon | Ε | ε | ϵ | Rho | Ρ | ρ | ϱ |
| Zeta | Ζ | ζ | | Sigma | Σ | σ | ς |
| Eta | Η | η | | Tau | Τ | τ | |
| Theta | Θ | θ | ϑ | Upsilon | Υ | υ | |
| Iota | Ι | ι | | Phi | Φ | φ | ϕ |
| Kappa | Κ | ϰ κ | *ϰ* | Chi | Χ | χ | |
| Lambda | Λ | λ | | Psi | Ψ | ψ | |
| Mu | Μ | μ | | Omega | Ω | ω | |

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

| Russian | English |
|---|---|
| sin | sin |
| cos | cos |
| tg | tan |
| ctg | cot |
| sec | sec |
| cosec | csc |
| sh | sinh |
| ch | cosh |
| th | tanh |
| cth | coth |
| sch | sech |
| csch | csch |
| arc sin | $\sin^{-1}$ |
| arc cos | $\cos^{-1}$ |
| arc tg | $\tan^{-1}$ |
| arc ctg | $\cot^{-1}$ |
| arc sec | $\sec^{-1}$ |
| arc cosec | $\csc^{-1}$ |
| arc sh | $\sinh^{-1}$ |
| arc ch | $\cosh^{-1}$ |
| arc th | $\tanh^{-1}$ |
| arc cth | $\coth^{-1}$ |
| arc sch | $\text{sech}^{-1}$ |
| arc csch | $\text{csch}^{-1}$ |

---

| Russian | English |
|---|---|
| rot | curl |
| lg | log |

## GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

MT/ST-77-0606

TEMPERATURE CONDITIONS OF THE WORK OF MATRIX/[redacted] DURING HOT PRESSING STEELS WITH GLASS LUBRICANT.

Yu. V. Manegin.

Pages 10-13.

The substantiated selection of material for the manufacture of matrix/dies can be made only in the presence of the data on specific loads and the thermal fields, which develop in matrix/die in the process of its operation. The temperature conditions of the work of matrix/dies in interrelation with the technological parameters of process during pressure forging steels are examined in this article based on materials of the investigations, carried out in this direction in the CRIFM [ЦНИИЧМ] im. Bardeen [1].

FOOTNOTE [1]. In work took part V. I. Pol'dyaev. ENDFOOTNOTE.

The temperature conditions of the work of matrix/die were studied during pressure forging steels in horizontal hydraulic press by effort/force 1500 ton-force. For the measurement of temperature was applied the cut construction of matrix/die with groove/slots for thermocouples (Fig. 1), which were placed in four points: in the beginning and middle of cone 1 and 2, in the place of the transition of cone to calibrating section 3 and in the body of matrix/die 4 [1]. Thermojunctions were welded at points 1, 2 and 3 on the surface of matrix/die and at depth 1.5 mm from surface. Readings of thermocouples were record/written by oscillograph H = 700. Simultaneously with temperature was record/written the effort/force of pressure forging. Blanks of steels U8 and Kh18N10 were heated to 1180-1200°C in resistance furnace with protective atmosphere, pressed from containers 80 and 120 mm in diameter with a coefficient of drawing of 4; 7.1 and 16.

Technological lubricant (glass) applied to the lateral surface of the heated blank by knurl. To matrix/die was packed the glass plate from glass or slag [2]. Pressure forging was realize/accomplished without butt, which was reached as a result of applying "false" disks from graphite.

The degree of the heating of matrix/die was studied depending on the ductility/toughness/viscosity of the used glass lubricant, coefficient of drawing, velocity of the pressure forging and other parameters. The picture of the heating of matrix/die during pressure forging the stainless steel with the application/use of a glass lubricant is given in Fig. 2. From diagram it follows that before pressure forging in matrix/die is a nonuniform by volume thermal field, which is establish/installed after the contact of cold girder with the heated to 350°C container. The maximum heating (~280°C) in this case falls on the zone of matrix/die, which directly contacts with container (point 1), and minimum (150°C) - to the interior of matrix/die (point 4).

In the process of pressure forging the matrix/die affects heat flux from the blank being deformed. This effect is realize/accomplished through the lubricating disk whose thickness is decreased from one point 1 to next 3. Because of this the surface of the working cone of the matrix/die is heated unevenly. A greatest increase in the temperature ($\Delta T$) occurs in the place of the transition of conical section to that which calibrate (point 3), where lubricant film is minimum. In surface layer an increase in the temperature in this zone composes $T_3 \cong 300°C$, at depth 1.5 mm $T_3 \cong$

200°C. By points 1 and 2 value of ΔT does not exceed 20-30°C. Thus, most heated in matrix/die is the zone of point 3, where the temperature of surface layer reaches 500°C. At depth 1.5 mm the temperature of layer amounts on the average to 400°C. Under specific conditions the temperature of matrix/die on the surface of zone 3, as this will be shown below, can exceed 650°C, i.e., exceed the temperature of the tempering of tool steel 3Kh2V8, from which are prepared the matrix/dies.

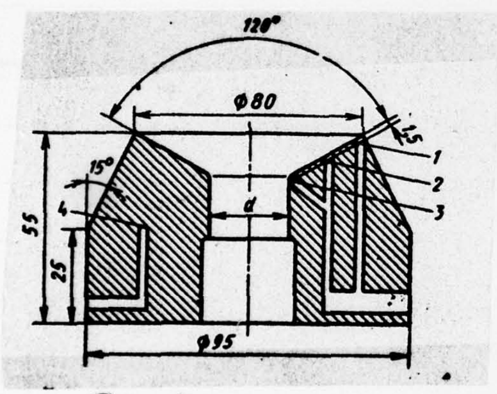


Fig. 1.

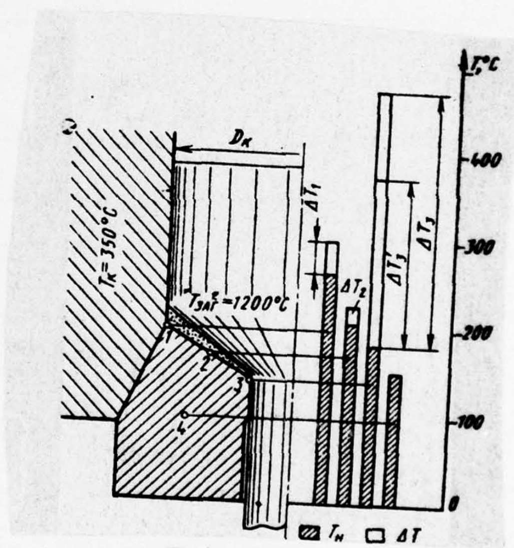


Fig. 2.

Fig. 1. Split die with groove/slots for thermocouples.

Fig. 2. The heating of matrix/die during the pressure forging: $T_H$ — is temperature of matrix/die to pressure forging ($\Delta T$) - the value of the heating of matrix/die during pressure forging (coefficient of drawing 7.1, the velocity of pressure forging [illegible] = 150 mm/s).

Page 11.

By this is explained the intense wear of matrix/die in the place of the transition of conical part to the calibrating mesh.

Since a change in the temperature of matrix/die in zones 1 and 2 during pressure forging is insignificant, at further experiments measurements temperature at depth 1.5 mm were not conducted.

In order to explain the degree of the protection of matrix/die from heating because of the application/use of a glass lubricant, which has, as is known, low thermal conductivity, were placed the experiments, in which the temperature of the heating of matrix/die was measured under the following conditions: during pressure forging with lubricating disk and without the lubrication of the lateral surface; during pressure forging without lubricating disk, but with the lubrication of the lateral surface by glass; during pressure forging without lubrication.

Figure 3a-d gives the typical oscillograms for all four versions of swabbing, obtained during pressure forging with the coefficient of drawing 7.1 and of velocity $v_{npec}$ = 200 mm/s. Full/total/complete molding cycle, from the beginning of the decompression of blank in container and before its full/total/complete extrusion of matrix/die, in these oscillograms can be determined by effort/force curve of pressure forging P. This cycle duration of approximately 2 s, whereupon more the half of this time falls on decompression. The smallest heating matrix/die is subjected to with the lubrication of the lateral surface knurl and the application/use of a lubricating disk, and also when using only one disk (Fig. 3a and b). In the zone of point 3 (see Fig. 2) the temperature of the heating of matrix/die in both cases is practically identical and it reaches $T_3$ = 500°C. The character and the value of the heating of matrix/die in the zones of points 1 and 2 are also identical. Sharply is changed the picture of the heating of the matrix/die, when is applied the only one lubrication of the lateral surface of blank (Fig. 3c). The temperature of matrix/die in the zone of point 3 (see Fig. 2) grow/rises to $T_3$ = 900°C. Intense heating is observed in the zones of points 1 and 2, where the temperatures grow/rise to $T_1$ = 680°C and $T_2$ = 650°C. An increase in the temperatures in these zones, as can be seen from oscillograms, it begins already in the period of the

decompression of blank in container. Similar pattern is observed during pressure forging without lubrication (Fig. 3d), but the level of heating in this case in all zones is somewhat less. This is explained by the fact that the process of pressure forging in the last/latter two cases proceeds with formation on the matrix/die of the "stagnation" zones, on which occurs the section/shear of metal. During pressure forging without lubrication the volume of the "stagnation" and cooled zone is considerably more; therefore the heating of matrix/die points 1, 2 and 3 somewhat less.

Thus, the basic protection of matrix/die from the effect of the high temperature of the blank being deformed is reached as a result of applying a lubricating disk. The glass lubricant, plotted/applied to the lateral surface of blank, does not fulfill heat-insulating functions [3]. As a result, the process of shaping metal is accomplished in the presence of the considerable contact forces of friction in matrix/die, which lead to the formation of "stagnant" zone.

In order to explain, in which measure the physical properties of glasses for disks affect the value of the heating of matrix/die, were carried out experiments with glasses of different ductility/toughness/viscosity. The physical characteristics of the tested glasses with viscosity values with 1200°C are given in Table 1.

Figure 4 shows the dependence of the temperature of the heating of matrix/die in different sections from the logarithm of the ductivity/toughness/viscosity of glass plate.

From the graph it follows that the ductility of the glass plate does not affect the heating of matrix/die in zones 1, 2 and 4. In zone 3 function $T_3 = f(\lg \eta)$ has outer limits. According to the character of the obtained dependence graph in Fig. 4, can be broken into three fields. In fields I and III are located the maximum values of the heating of the matrix/dies, which are related to the cases of applying disks from glass of low and high viscosity (43 and 200,000 poise). Field II - this is the field of the ductility/toughness/viscosity of glasses from 226 to 19,000 poise, which possess the maximum heat-insulating properties. This same field includes the blast-furnace slag.

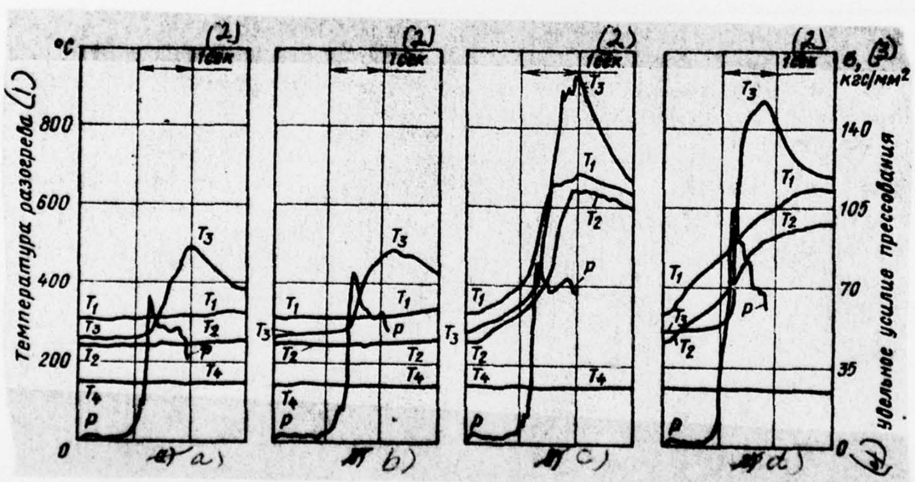


Fig. 3.

Fig. 3. The oscillograms of the process of pressure forging for the diverse variants of swabbing: a) the application/use of a knurl and lubricating disk; b) the application/use of one lubricating disk; c) the application/use of one knurl; d) pressure forging without lubrication; P is an effort/force of pressure forging.

Key: (1). Temperature of heating. (2). s. (3). kgf/mm². (4). Specific effort/force of pressure forging.

Table 1. Physical properties of glass lubricants.

| (1) № стекла | (2) Вязкость в Пз при 1200 °C | (3) Теплопроводность в кал/см · с · град | (4) Теплоемкость в кал/г · град |
|---|---|---|---|
| 271 | 43 | 0,0027 | 0,1727 |
| 209 | 226 | 0,0025 | 0,1916 |
| 287 | 500 | 0,0031 | 0,1957 |
| 10пб | 1 200 | 0,0025 | 0,1997 |
| 124 | 6 500 | 0,0023 | 0,1984 |
| 19пб | 19 000 | 0,0025 | 0,1980 |
| 224-18 | 200 000 | 0,0026 | 0,2044 |

Key: (1). No glass. (2). Ductility/toughness/viscosity in poise with 1200°C. (3). Thermal conductivity in cal/cm•s•deg. (4). Heat capacity in cal/g•deg.

Page 12.

When using these forms of lubrications is reached the minimum heating

of matrix/die. An increase in the temperature of matrix/die ($T_3$) during the application/use of disks with low ductility/toughness/viscosity (43 poise) can be explained by the fact that the glass plate with such properties rapidly melts to large depth, and glass intensely it squeezed out of the deformation area. As a result can be observed the short-time contact of the metal being deformed with matrix/die [4].

An increase in the temperature of the heating of matrix/die when using glass plates with ductility/toughness/viscosity 200,000 poise is caused by another reason. In this case the glass plate does not manage to be fused at the necessary depth, as a result of which lubricant film has an insufficient thickness and a thermal conductivity from metal to matrix/die is increased.

About the fact that the thickness of lubricant film during pressure forging depends on the ductility/toughness/viscosity of glass lubricant, showed the data, obtained by the gravimetric method, on the expenditure/consumption of lubricating disk. The averaged thickness of film when using glass with ductility/toughness/viscosity 50 poise composed ~17 μ, and glass with ductility/toughness/viscosity 200000 poise ~5 μ. Experiments with glasses of different ductility/toughness/viscosity give grounds to consider that the basic factor, which determines the value of the heating of matrix/die, is

the thickness of the lubricant film, which depends, in turn, from other technological parameters of process, which it is discussed in work [5].

Table 2 gives the average values on the heating of matrix/dies depending on the coefficient of drawing, velocity of pressure forging and method of pressure forging. According to the findings established/installed that with an increase in the degree of the deformation the heating of matrix/die in the zone of point 3 (see Fig. 2) it is increased. For example, during pressure forging with a coefficient of drawing of 4 heating composed $T_3$ = 415°C, and during strain with drawing 16 temperature was increased to $T_3$ = 530°C. The character of a change in the temperature of matrix/die in the zones of points 1 and 2 at an increase in the drawing virtually is not changed.

Temperature rise and the heating of matrix/die in the zone of point 3 at an increase in the drawing can be explained by an increase in the temperature of metal because of the work of strain, increase in the specific load and certain deceleration of pressure forging. All these factors one way or another affect the thickness of lubricant film and its thermal resistance.

A change in the velocity of pressure forging differently

manifests itself the heating of matrix/die in the case of the utilization of a lubricating disk from glass and disk from blast-furnace slag. At the rates of pressure forging $v_{прес}$ = 220 mm/s the temperature of the heating of matrix/die in both cases differs little from each other ($T_3$ = 550°C and 570°C), (see Table 2).

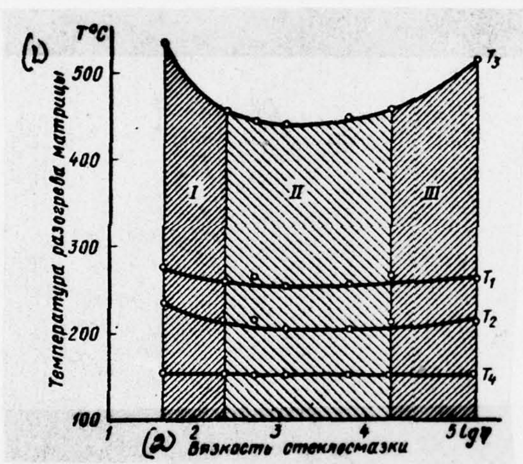


Fig. 4

Fig. 4. Dependence of the temperature of the heating of matrix/die from the viscosity of the glasses, used for lubricating disks.

Key: (1). Temperature of the heating of matrix/die. (2). Viscosity of glass lubricant.

Table 2. Data on the heating of matrix/dies during pressure forging steels.

| (1) Параметры прессования | | | | | | (2) Смазка | | (3) Температура матрицы до прессования в зонах точек 1, 2 и 3 (см. рис. 2) | | | (4) Время прессования в с | (5) Температура матрицы после прессования в зонах точек 1, 2 и 3 (см. рис. 2) | | | (6) Примечание |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (7) Материал | (8) Диаметр контейнера в мм | (9) Температура печи в °C | (10) Коэффициент вытяжки μ | (11) Удельное усилие в кгс/мм² | (12) Скорость в мм/с | (13) Накатка | (14) Шайба | $T_1$ | $T_2$ | $T_3$ | | $T_1$ | $T_2$ | $T_3$ | |
| X18H10 | 80 | 1200 | 4 | 43 | 160 | 271 | (15) доменный шлак | 240 | 180 | 180 | 1,1 | 250 | 190 | 415 | — |
| | 80 | 1200 | 7,1 | 65 | 165 | 271 | То же | 270 | 210 | 230 | 1,1 | 270 | 210 | 470 | |
| | 80 | 1200 | 16 | 79 | 100 | 271 | » | 310 | 290 | 215 | 1,8 | 350 | 300 | 530 | |
| X18H10 | 80 | 1200 | 7,1 | 41 | 150 | 271 | » | 270 | 210 | 240 | 1,2 | 290 | 215 | 530 | (16) Прессование с пресс-остатком |
| | 80 | 1200 | 16 | 72 | 72 | 271 | » | 290 | 290 | 254 | 2,5 | 370 | 395 | 650 | |
| У8 | 120 | 1200 | 16 | 37 | 30 | 271 | » | 280 | 250 | 210 | 6,0 | 280 | 250 | 485 | — |
| | 120 | 1200 | 16 | 41 | 70 | 271 | » | 315 | 280 | 285 | 2,1 | 325 | 280 | 540 | |
| | 120 | 1200 | 16 | 53 | 220 | 271 | » | 315 | 280 | 285 | 0,8 | 320 | 280 | 570 | |
| | 120 | 1200 | 16 | 36 | 30 | 271 | 209 | 290 | 260 | 225 | 6,0 | 335 | 335 | 660 | |
| | 120 | 1200 | 16 | 45 | 90 | 271 | 209 | 295 | 260 | 230 | 2,0 | 295 | 260 | 580 | |
| | 120 | 1200 | 16 | 54 | 220 | 271 | 209 | 325 | 295 | 290 | 0,8 | 325 | 295 | 550 | |

Key: (1). Parameters of pressure forging. (2). Lubrication. (3). The temperature of matrix/die tc pressure forging in the zones cf pcints 1, 2 and 3 (see Fig. 2). (4). Time of pressure forging in s. (5). The temperature of matrix/die after pressure forging in the zones of points 1, 2 and 3 (see Fig. 2). (6). Note. (7). Material. (8). Diameter of container in mm. (9). Temperature cf furnace in °C. (10). Draw ratio and. (11). Specific effort/force in kgf/mm². (12). Velocity in mm/s. (13). Knurl. (14). Disk. (15). Blast-furnace slag. (15a). The same. (16). Pressure forging with butt.

Page 13.

During a decrease in the velocity down to $v_{пред}$ = 30 mm/s and the during utilization of a disk from glass № 209 heating of matrix/die in the zone of point 3 is increased by 100°C and it reaches $T_3$ = 660°C, while when using a disk from slag the temperature at the same rate descends to 85°C and it composes $T_3$ = 485°C. The character of a change in the heating of matrix/die when using two types of lubricating disks is visually cbservable from the oscillograms, given in Fig. 5. The shape of the curve of the temperature of the heating cf matrix/die $T_3$ when using a slag disk is characterized by insignificant change during molding cycle (Fig. 5a). During the application/use of a glass plate the course of the temperature curve

of the heating of matrix/die in zone 3 is characterized by constant lift from beginning to the end of the pressure forging (Fig. 5c). In this case is observed the higher lift of temperature curves for the zones of points 1 and 2 (see Fig. 2). The different shape of the curve of the heating of matrix/die when using disks from glass and slag can be explained by a difference in the properties of these materials. Slag, as is known, is vitreo-crystalline substance, and its viscosity in the temperature range of the strain of steels is changed with temperature change more sharply than of amorphous glasses [2]. Furthermore, of blast-furnace slag significantly higher the temperature of liquefaction. In connection with this during pressure forging at low velocity slag disk is fused in a thiner surface layer and more uniform is expend/consumed. Under these conditions the disk of amorphous glass of low viscosity is expend/consumed more intensely and as a result toward the end of the process-lubrication can be insufficient for the creation of the reliable heat-insulating layer.

As noted above, all experiments in the investigation of the heating of matrix/die were conducted during pressure forging without butt. With this method of pressure forging the time of the contact of metal with matrix/die is less than during pressure forging with butt. It is natural that and the degree of the heating of matrix/die in the first case will be less. The difference in the value of the heating

of matrix/die in the zone of point 3 during pressure forging by different methods as showed the experiments, it reaches ~100°C. Consequently, during pressure forging without butt are provided the more favorable conditions of the service of matrix/dies, and their life can be more.

Conclusions. 1. The greatest heating of matrix/die is observed in the place of the transition of conical part to the calibrating mesh. The combination of high heating and large loads leads to the intensive wear of this zone of matrix/die.

2. The basic heat shield of matrix/die from heating is reached as a result of applying a lubricating disk. When using this form of lubrication descends the heating of matrix/die to 400°C and more.

3. The value of the heating of matrix/die depends on the properties of the used lubricating disk, coefficient of drawing, velocity and method of pressure forging (with butt or without it).

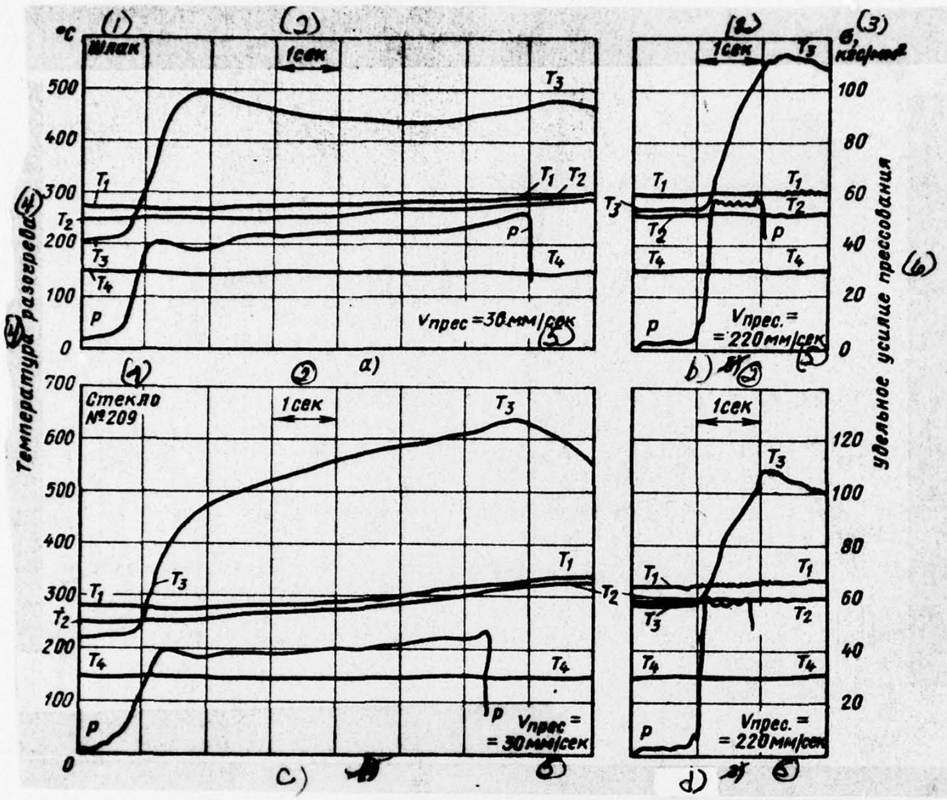


Fig. 5. Oscillograms of process at the different velocities of the pressure forging: a and b) pressure forging with the application/use of a lubricating disk from slag; c and d) pressure forging with the application/use of a lubricating disk from glass.

Key: (1). Slag. (2). s. (3). kgf/mm². (4). Temperature of heating. (5). mm/s. (6). Specific effort/force of pressure forging. (7). Glass.

Page 18

BIBLIOGRAPHY


1. Манегин Ю. В., Польдяев В. И. Экспериментальное определение теплового поля матрицы при горячем прессовании стали «Материалы четвертого научно-технического совещания по вопросам прессования металлов», М., «Металлургия», 1970.

2. Анисимова И. В. и др. Использование доменного шлака в качестве смазки при горячем прессовании труб из нержавеющей стали — «Бюллетень ЦНИИЧМ и ТЭИЧМ», № 21 (641), 1970.

3. Rowe G. W., Golden I. A. «Scient. Lubrical», 13, № 4, 1961.

4. Гуляев Г. И., Дробич О. П. Технологические смазки, применяемые при прошивке заготовок и прессовании стальных труб и профилей. — «Материалы третьего научно-технического совещания по вопросам прессования металлов», М., «Металлургия», 1968.

5. Томленов А. Д. О критической толщине смазочного слоя при обработке металлов давлением. — «Кузнечно-штамповочное производство», 1972, № 3.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>FTD-ID(RS)T-0606-77 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>TEMPERATURE CONDITIONS OF THE WORK OF MATRIX DURING HOT PRESSING STEELS WITH GLASS LUBRICANT | | 5. TYPE OF REPORT & PERIOD COVERED<br>Translation<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Yu. V. Manegin | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Foreign Technology Division<br>Air Force Systems Command<br>U. S. Air Force | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 12. REPORT DATE<br>1972<br>13. NUMBER OF PAGES<br>18 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

13

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

## DISTRIBUTION LIST

## DISTRIBUTION DIRECT TO RECIPIENT

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| A205 | DMATC | 1 |
| A210 | DMAAC | 2 |
| B344 | DIA/RDS-3C | 8 |
| C043 | USAMIIA | 1 |
| C509 | BALLISTIC RES LABS | 1 |
| C510 | AIR MOBILITY R&D LAB/FIO | 1 |
| C513 | PICATINNY ARSENAL | 1 |
| C535 | AVIATION SYS COMD | 1 |
| C557 | USAIIC | 1 |
| C591 | FSTC | 5 |
| C619 | MIA REDSTONE | 1 |
| D008 | NISC | 1 |
| H300 | USAICE (USAREUR) | 1 |
| P005 | ERDA | 1 |
| P055 | CIA/CRS/ADD/SD | 1 |
| NAVORDSTA (50L) | | 1 |
| NAVWPNSCEN (Code 121) | | 1 |
| NASA/KSI | | 1 |
| [redacted] | | [redacted] |
| AFIT/LD | | 1 |

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| E053 | AF/INAKA | 1 |
| E017 | AF/ RDXTR-W | 1 |
| E404 | AEDC | 1 |
| E408 | AFWL | 1 |
| E410 | ADTC | 1 |
| E413 | ESD | 2 |
| | FTD | |
| | CCN | 1 |
| | ETID | 3 |
| | NIA/PHS | 1 |
| | NICD | 5 |